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# ***2016 ASGSR MaterialsLab Overview***

***October 27, 2016***



# Thermophysical Properties Reference Experiment

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**Science Definition Team:** Jan Rogers (NASA MSFC), Michael SanSoucie (NASA MSFC), Dennis Tucker (NASA MSFC), Martin Volz (NASA MSFC), **Ranga Narayanan** (University of Florida, Gainesville), Satoshi Matsumoto (JAXA), Kevin Ward (University of Florida, Gainesville), **Douglas Matson** (Tufts University), Mikhail Krivilev (Udmurt State University), Vijay Kumar (Tufts University), Masahito Watanabe (Gakushuin University), Takehiko Ishikawa (JAXA), Hiroyuki Fukuyama (Tohoku University), Shumpei Ozawa (Chiba Institute of Technology), Geun Woo Lee (KRISS), Andreas Meyer (DLR), Hans Fecht (University of Ulm), Rainer Wunderlich (University of Ulm), G. Pottlacher (TU-Graz), Kenneth Kroenlein (NIST), **Richard Weber** (Materials Development, Inc.), Shinji Kohara (National Institute for Materials Science (Japan)), Jonghyun Lee (University of Massachusetts), Oliver Alderman (Materials Development, Inc.), Anthony Tamalonis (Materials Development, Inc.), **Robert Hyers** (University of Massachusetts), Joonho Lee (Korea University), **Aleksandar Ostrogorsky** (Illinois Institute of Technology), Prof. G.N. Kozhemyakin and Dr. A.E. Voloshin (Russian Academy of Sciences)

**Collaboration:** Russia, Japan, Germany, South Korea, Austria, NIST, Materials Development Inc.

**ISS Facility/Hardware:** JAXA ELF, MSRR/LGF

**Microgravity Justification:** Very well-controlled fluid flow is required for precise measurements of thermophysical properties. Microgravity provides a high degree of control over transport processes that cannot be achieved on earth. Ground experiments of interfacial tension are heavily influenced by gravity.

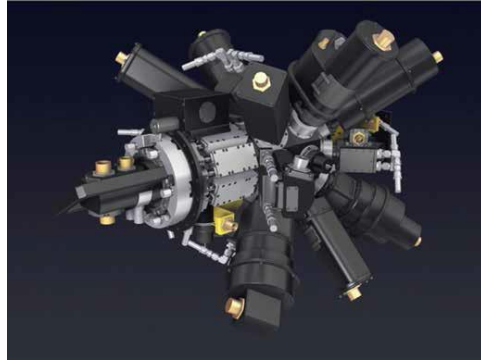
**Application/Impact:** Many industrial processes, photonics (metal oxides), lasers, optical communications, imaging, holographic storage, adaptive optics, phase-conjugate mirrors, beamed energy, and semiconductors.

**PSI Significance:** NIST reviewed and assessed proposals. NIST indicated that the proposed reference experiment is well aligned with MGI and its goal of accelerating materials development and

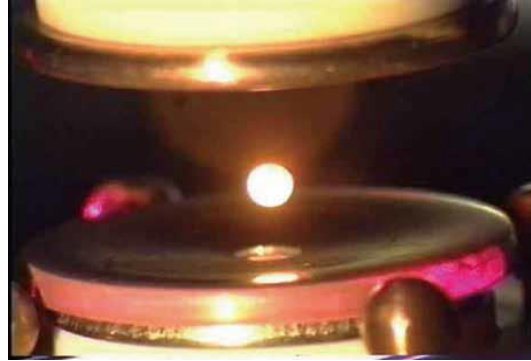
This Reference Experiment will provide a great deal of data for a large variety of materials with impact on many industries. Therefore we expect high usage of this data.



# Thermophysical Properties Reference Experiment



Model of ELF hardware



Levitated sample in the ELF ground unit

Thermophysical Properties measurements are enabled by microgravity

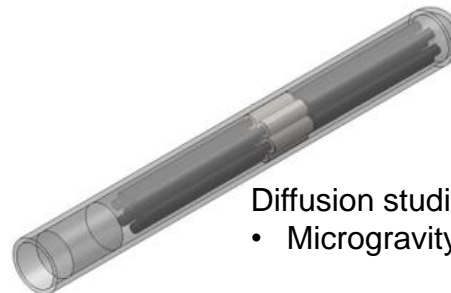
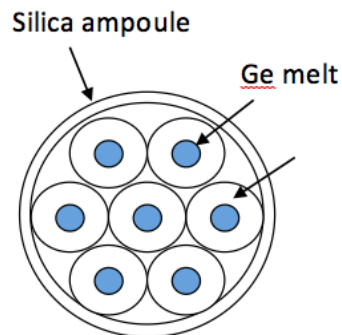
- More perfect spheres provide more accurate measurements
- Reduced position forces provide more quiescent flow of molten samples
- Provides a high degree of control over transport processes that cannot be achieved on earth
- Minimize density-driven segregation

**ELF Proposers:** Ranga Narayanan, Douglas Matson, Richard Weber, Robert Hyers

Microgravity enables high-quality thermophysical property measurements for properties and materials that are sensitive to gravity-driven phenomena such as buoyancy-driven fluid flows and sedimentation. Experiment requirements dictate selection of ISS Research Facility.

**SCA Proposer:**

- Aleksandar Ostrogorsky



Diffusion studies require quiescent melts (no bulk flow)

- Microgravity is necessary to meet this requirement

Bundle of capillary tubes in a SCA



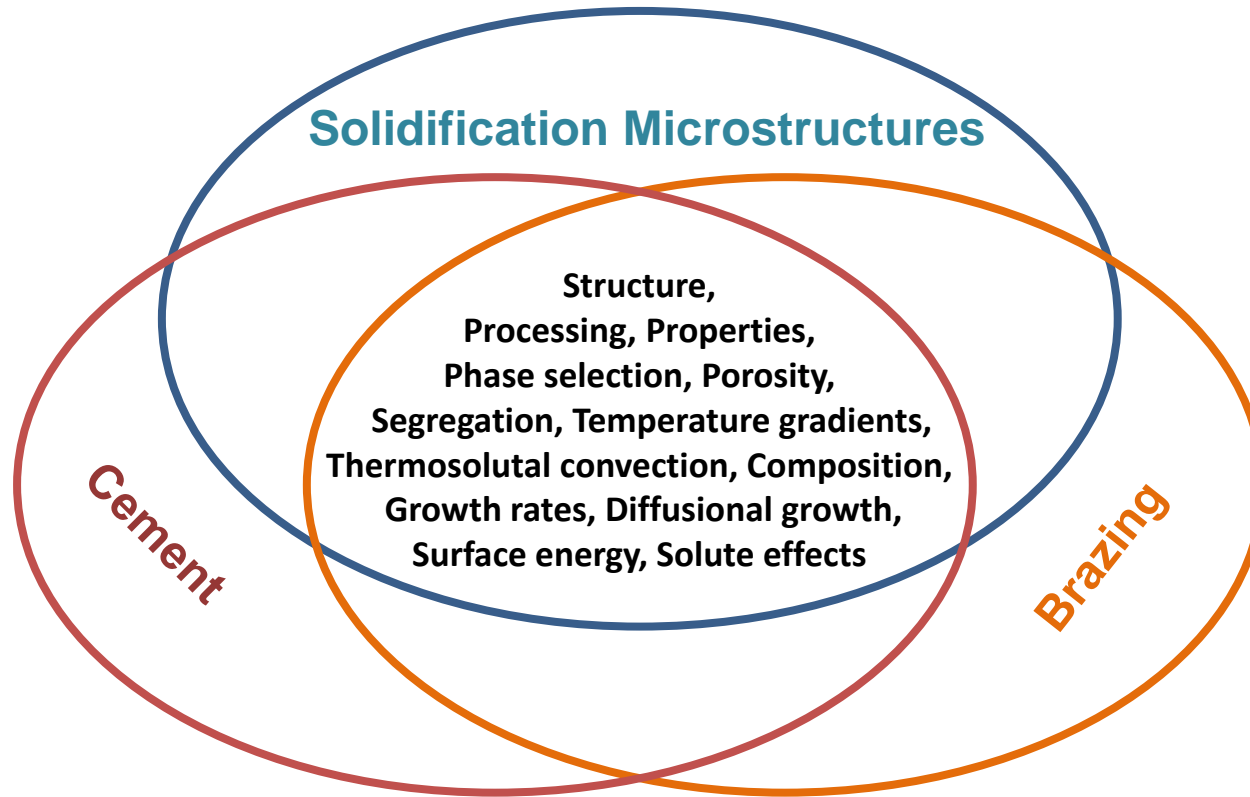
# Thermophysical Properties Reference Experiment



Title / Proposer	Measurement	Samples	Objectives	Impact	NIST Comments
A Novel Way to Measure Interfacial Tension Using the Electrostatic Levitation Furnace / Narayanan	Interfacial Tension	Zr, Au, Pt	A novel method to measure interfacial tension (IFT). Use of Faraday instability via electrostatic forcing to measure the IFT between a liquid and its surrounding atmosphere	Novel measurement technique useful for several materials and applicable to several industrial processes (semiconductors, oil recovery, welding, etc.)	On a purely "NIST" basis, this might have been the top ranked proposal. That is, this proposal focusses on how to measure a specific property better.
Round Robin - Thermophysical Property Measurement / Matson	Density, Surface Tension, Viscosity	Zr, TiZrNi, Steel, FeNi, Pt, Au, Zr w/ 3% O <sub>2</sub> in solution	Understand and control the sources of measurement error and to provide a baseline dataset for quantifying uncertainty in measurements (both space- and ground-based)	Baseline dataset (ensures the highest quality data). Proposed materials have industrial applications (casting, nuclear fuel rods, metallic glass)	Best proposal in terms of meeting MaterialsLab goals, objectives, and philosophy. The proposers seemed to have the best understanding of, and dedication to, the team science philosophy.
Microgravity Investigation of Thermophysical Properties of Supercooled Molten Metal Oxides / Weber	Density, Surface Tension, Viscosity	Al <sub>2</sub> O <sub>3</sub> , Ca <sub>12</sub> Al <sub>14</sub> O <sub>33</sub> , CaAl <sub>2</sub> O <sub>4</sub> , CaSiO <sub>3</sub> , MgSiO <sub>3</sub> , Al <sub>6</sub> Si <sub>2</sub> O <sub>13</sub> , FeSiO <sub>3</sub> , YbAlO <sub>3</sub> , YbLa <sub>2</sub> Al <sub>5</sub> O <sub>12</sub> , etc.	Accurate measurements of thermophysical property data for molten metal oxides. A greater understanding of the glass transition and of the requirements for optimizing and processing.	High value-added glass materials that are used in photonics, lasers, optical communications, and imaging applications	Highest potential impact to MGI goal of accelerating materials development and commercialization, i.e. expected relevance of the data obtained to the development of new materials that could then lead to new products and jobs.
Thermophysical Properties and Transport Phenomena Models and Experiments in Reduced Gravity / Hyers	Density, Surface Tension, Viscosity	Bi <sub>12</sub> SiO <sub>20</sub> , Bi <sub>12</sub> GeO <sub>20</sub>	Advance the understanding of photorefractivity. Measured properties will be used to model and test theories about the effect of processing on microstructure and material characteristics.	Potential to enable several new kinds of photonic devices, e.g. holographic storage, adaptive optics, phase-conjugate mirrors, beamed energy	Good, knowledgeable, team proposing good work. Has potential for great rewards if it hits. If we were reviewing these proposals on an "NSF" basis, this would probably be the top ranked proposal.
Diffusion Coefficients of Dopants in Si and Ge Melts / Ostrogorsky	Diffusion Coefficients	Ge; Diffusing species: Ga, B, Sb, Si	Investigate and measure the diffusion coefficients of several dopants in Ge.	Differences in size and electronic structure of the selected dopants will influence properties and diffusion rates. Applications include novel transistors, detectors, and photovoltaics.	This work addresses critical fundamental measurement science issues relevant to materials processing for a very important industry (i.e. semiconductor industry).



# Microgravity Materials Processing



Three reference experiments, different in appearance, are united with the same parameters and goal:  
Utilize microgravity to understand the governing physics to improve material performance.





# Cement Reference Experiment



**Science Definition Team:** Dr. Richard Grugel (NASA MSFC), Prof. Aleksandra Radlińska (Penn State), Mr. Dale Benz (NIST), Prof. Barry Scheetz (Penn State), Dr. Jeffery Bullard (NIST), Dr. James Pawelczyk (Penn State), Ms. Annmarie Ward (Penn State), Sauereisen Corporation, BASF Corporation, and IPA Systems.

**Collaboration:** CASIS (crew time), NIST

**ISS Facility/Hardware:** Maintenance Workbench Area, MSG

**Objectives:** This is a benchmark experimental study applicable to 1) NASA extraterrestrial infrastructure development utilizing in situ materials and 2) advancing our knowledge of Earth-based processing. Microgravity processing negates thermo-solutal convection and buoyancy effects. This will change microstructural development in the hardening of cement paste and, upon analysis, will shed considerable light on crystal hydration kinetics, phase formations, pore distribution, and material properties. Improved cement properties leads to less cement required, which means less CO<sub>2</sub> emissions.

**Application/Impact:** As gleaned from a partially successful BASF *microgravity* experiment, one outcome is smaller growth of detrimental crystals; exploiting this could significantly increase mortar strength. Considerable commercial interest is anticipated and three industrial partners (BASF, IPA, and Sauereisen) are already contributing to the research dialogue, implementation steps, and providing materials.

**PSI Significance:** Dozens of simple, but scientifically complex, experiments will be conducted yielding an abundance of crystal morphologies, chemistries, orientations, distributions, growth kinetics, and mechanical properties for the PSI database.



Conceptually Simple "Burst Seal"



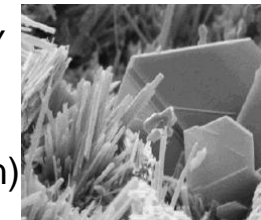
and Syringe Experiments



Strongly supports STEM



Easily Done on Earth and the ISS



Quickly Returned for Analysis



# Solidification Microstructure Reference Experiment



**Science Definition Team:** Dr. Richard Grugel (NASA MSFC), Prof. Peter Voorhees (Northwestern Univ.), Prof. Surendra Tewari (Cleveland State Univ.), Dr. Emine Gulsoy (Northwestern Univ.), Dr. Mohsen Eshraghi (California State Univ.- Los Angeles), Prof. Sergio Felicelli (Univ. of Akron).

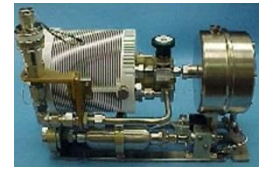
**Collaboration:** Industrial researchers are being contacted.

**ISS Facility/Hardware:** MSRR, LGF, SCA, CSLM apparatus.

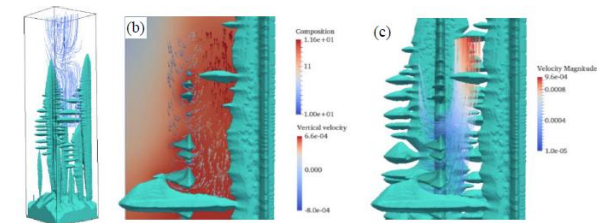
**Objectives:** Lead-Tin and Lead-Antimony alloys will be used to understand the role thermosolutal convection plays in dendritic pattern formation and initiating secondary arm fragments (now effectively defects), factors that significantly influence mechanical properties. Only solidification experiments carried out in the ISS microgravity environment can provide such data.

**Application/Impact:** The results are relevant to commercial casting practices. Understanding the role of convection on microstructural development can lead to novel mold designs which will improve material properties of components such as turbine blades and lighter, stronger, engine blocks. Directional solidification and knowledge of defect formation will provide significant MGI type modeling and new material development relevant data for MGI (NIST).

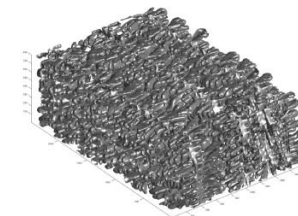
**PSI Significance:** The Science Definition Team (RG, PV, and ST) has already contributed *terabytes* to the Physical Science Informatics from previously conducted ISS experiments. Some of these data (CSLM and PFMI) will be used by Investigators of recently awarded PSI proposals. Results from this Reference Experiment will complement that previous work and greatly expand the database.



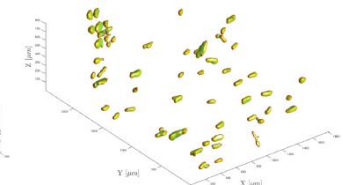
Utilizes Existing and Proven Hardware



Fluid flow and solute distribution about Pb-Sn dendrites growing under natural convection.



3D reconstruction of a Pb-Sn alloy, dendrite fragments revealed



State-of-the-Art Metallographic Analysis and Modeling will be Employed



# Brazing Reference Experiment



**Science Definition Team:** Dr. Richard Grugel (NASA MSFC), Prof. Dusan Sekulic (Univ. of Kentucky), Prof. Mikhail Krivlev (Udmurt State Univ. Russia), Dr. David Seveno (KU Leuven, Belgium), Dr. Sinisa Mesarovic (Washington State).

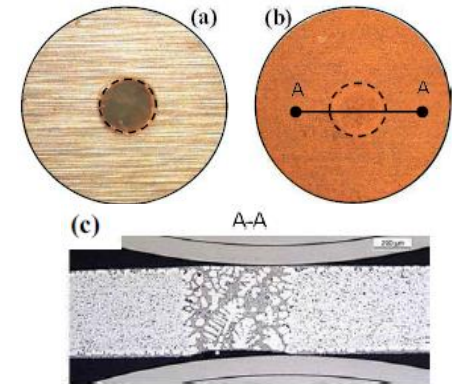
**Collaboration:** Russia (Crew time) and Belgium

**ISS Facility/Hardware:** MSRR, LGF, SCA, or SUBSA: Video optional.

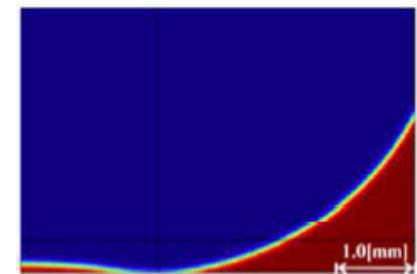
**Objectives:** Space experiments devoted to the problem of metallurgical brazing have been conducted by both NASA and Roscosmos starting with Skylab (1973-74) and Soyuz-6 (1969). Results of other Russian investigations (compiled by Paton 2003) and parabolic flights (Plester 1995, Langbun 1990) have also been reported. These studies provided proof-of-concept but offered no detailed analysis of the joining mechanism, particularly in the context of processing kinetics (enhanced wetting, spreading, capillarity) in a microgravity environment. The objective of this study is to quantify the brazing process through a series of experiments for NASA microgravity applications.

**Application/Impact:** Application would involve transferring the knowledge gained and adapting it to brazing in space for repair of pressure walls, and in situ construction. This will impact safety considerations and extraterrestrial infrastructure development.

**PSI Significance:** Relevant data from previous “demonstration” microgravity joining experiments are limited. Brazing encompasses a myriad of factors in determining the final microstructure, and its value as a joining technique. The amount of accurate physical data generated, coupled with the detailed modeling effort, will meaningfully contribute to the PSI database.



Terrestrial hole-in-plate experiment s. (a) Before brazing, (b) After brazing, (c) Sample cross-section: A-A



Simulation of the thin liquid film breakup in a T-joint configuration on a flat solid surface.





# Freeze Casting Reference Experiment

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**Science Definition Team :** S. Gorti (NASA), L. Strutzenberg (NASA), R. Grugel (NASA), U. Wegst (Dartmouth), D. Dunand (Northwestern), Fridon Shubitidze (Dartmouth), Alain Karma (NEU), Rohit Trivedi (AMES), Peter Voorhees (Northwestern)

**Facilities:** Pore Formation and Mobility Investigation module (PFMI).

**Objectives:** A considerable knowledge gap of the materials science of freeze casting exists. For Freeze Casting methodology to become a viable process, correlations between physical observables of directional solidification and the final formed structure, with the aid of computational models, is essential. There are two components within a freeze casting process: solvent and the suspension. In the absence of the suspension, directional solidification of the solvent is well-understood. The directional solidification of solvent becomes considerably more complex when suspensions of particles with polymer binders are introduced. Reference experiments are thus defined to investigate particulars of forming complex scaffolds using the freeze casting methodology.

**Microgravity Justification:** Freeze Casting Suspensions are not subjected to sedimentation or convective forces during solidification processes.

**Application/Impact:** Future of space travel may well be dependent on our ability to manufacture much needed high-strength, low-weight structural and non-structural materials, in-situ. The need for producing high-strength, low-weight materials for space travel and habitat development has long been recognized. A limiting factor has been the lack of processing methodologies capable of producing high-strength, low-weight materials, in both terrestrial and space environments. Freeze casting methodology is a highly attractive process for production of high-strength, low-weight material, which can be applied to all classes of materials: polymers, ceramics, metals and composites.

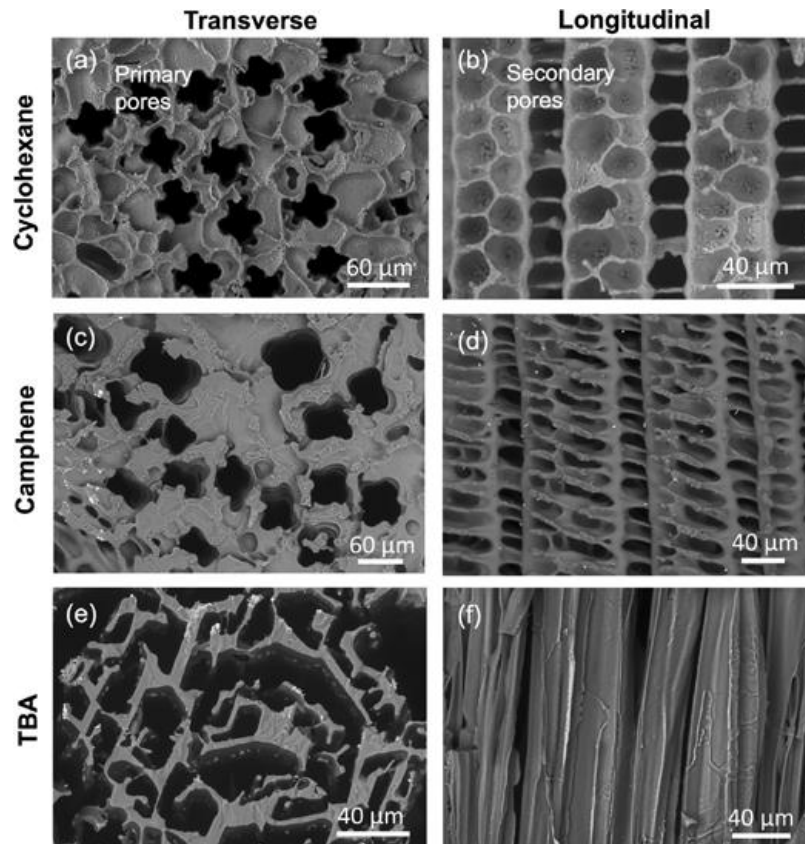
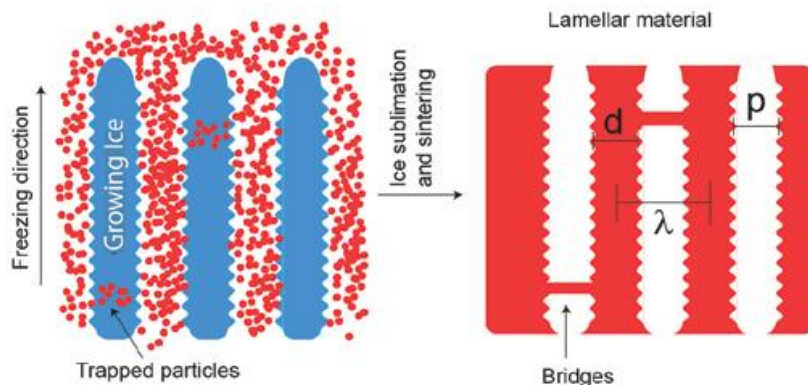
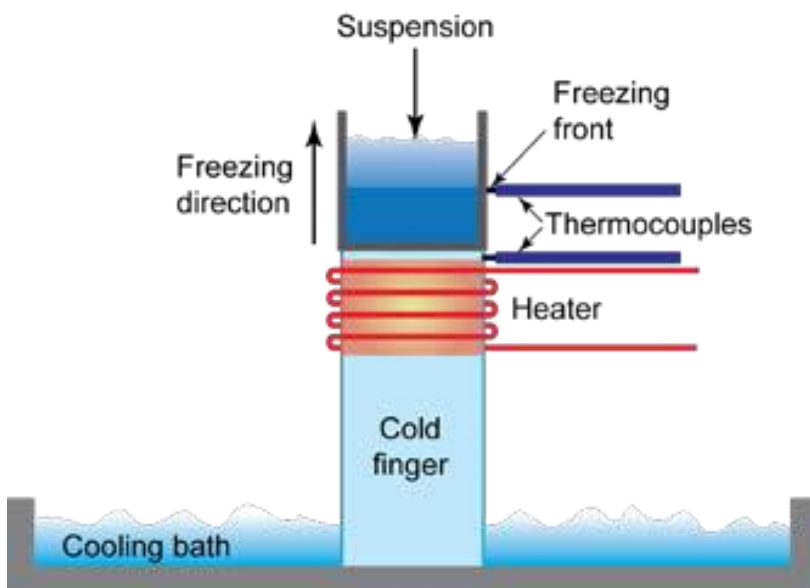
**PSI Significance:** High. This Reference Experiment will provide data for a large variety of materials with impact on many industries, products, and applications, some of very high value.



# Freeze Casting Reference Experiment



## Typical Freeze Casting Methodology



Fundamental solidification processes (left) giving rise to periodic patterned structures (above) yielding light-weight high strength structures. Microgravity can permit the growth of much larger, periodic structures.



# Biofilms MaterialsLab Reference Experiments



## Polymicrobial biofilm growth and control during spaceflight

**PI:** Robert McLean (TSU)

**Co-Is:** Cheryl Nickerson (Biodesign Institute, ASU), Mark Ott (NASA/JSC), Jennifer Barrila (Biodesign Institute, ASU), Simon Clemett (NASA/JSC), Mayra Nelman-Gonzalez (Wyle)

**Graduate Student:** Starla Thornhill (TSU)

## Characterization of Biofilm Formation, Growth, and Gene Expression on Different Materials and Environmental Conditions in Microgravity

**PI:** Luis Zea (U. Colorado)

**Co-Is:** David Klaus (U. Colorado), Ralf Moeller (DLR), Frank Muecklich (Saarland U.), Louis Stodieck (U. Colorado), Brenda Little (NRL)

### Objective:

**McClean Team:** Investigate the structure by which two-species, mixed-culture biofilms form under microgravity on stainless steel used to construct Environmental Controls and Life Support Systems (ECLSS) on the ISS. This project investigates the efficacy by which mixed-culture biofilms can be controlled, and whether microgravity-grown mixed-culture biofilms cause corrosion on stainless steel.

**Zea Team:** Characterize biofilm growth during one ISS increment in terms of mass, thickness, morphology, and associated gene expression using different spaceflight-relevant microbial species and different material substrata. This project also aims to elucidate the biomechanical and transcriptomic mechanisms involved in the formation of the “column-and-canopy” biofilm architecture observed in space.

### Collective Relevance/Impact:

#### Space Exploration

- Understand the physical interactive mechanisms of space flight relevant bacteria to materials
- Investigate the role these organisms and biofilm product play in material corrosion and degradation
- Provide insight into biofouling of materials that could play a role in materials and equipment failure
- Gain new knowledge to improve methods and material properties to control or eliminate biofilm formation during long duration space flight missions

#### Fundamental Space Biology:

- Investigate the mechanisms and morphology of biofilm formation in microgravity
- Understand the influence of materials on the formation of biofilms and impacts on gene expression

#### Astronaut Health:

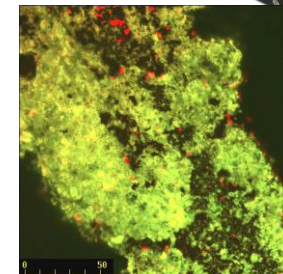
- Assess surface disinfectants on biofilm and microbial viability



Dr. Robert McLean



Dr. Luis Zea



P. aeruginosa Biofilm



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# *Questions on MaterialsLab Phase I*



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# Physical Sciences Informatics System





# PSI - Physical Sciences Informatics System

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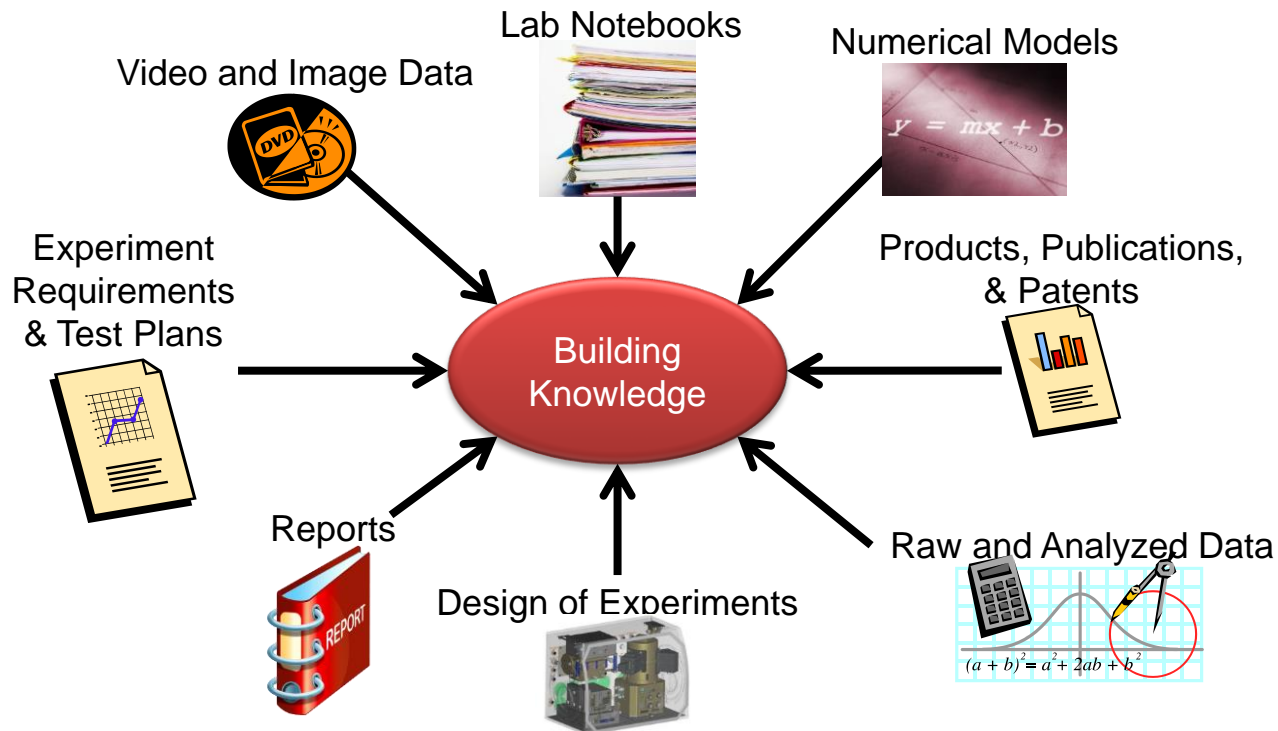


At NASA, we have developed the Physical Science Informatics (PSI) System, a data repository for physical science experiments performed on the International Space Station (ISS). The PSI system has been accessible and open to the public since Nov. 1, 2014, thus fulfilling the President's Open Data Policy. The website is: <http://psi.nasa.gov/>

“The resulting data from that envelope of experiments will then be used to create experimental informatics libraries that will support many more investigators and funded ISS-derived research. What that does is, it converts what would be normally a single [Principal Investigator] PI research opportunity into multiple PI research opportunities now and into the future”. Marshall Porterfield, Space Life and Physical Sciences Director.

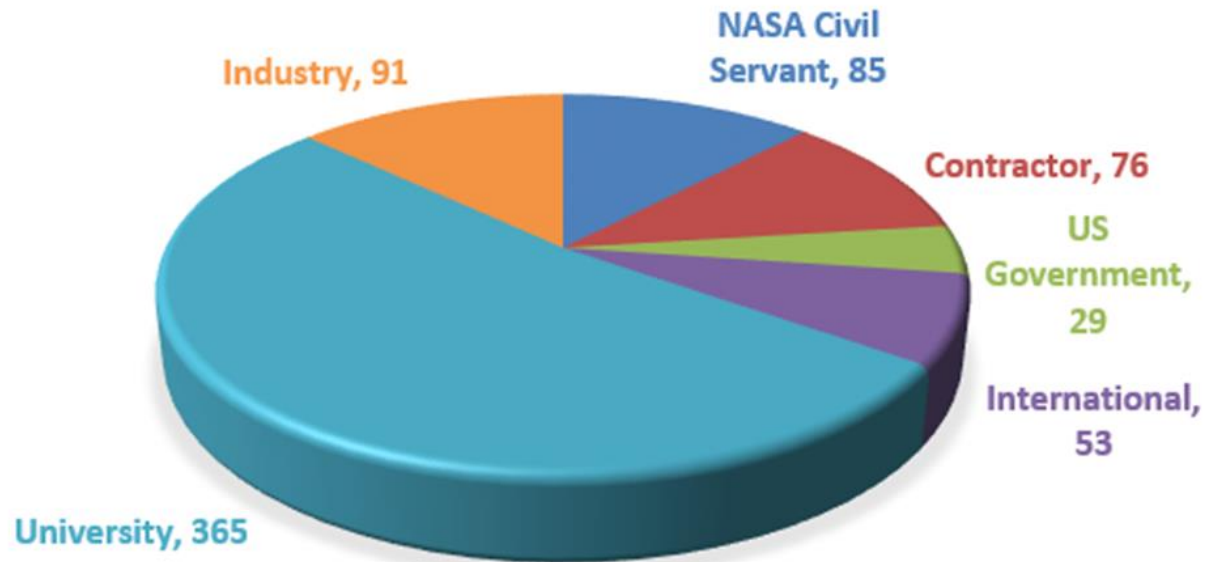


# Elements of PSI – Turning Data into Knowledge





# PSI User Demographic



Current total = 699  
(as of October 14th)



## PSI NRA - release dates and selections

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- PSI NRA Appendix A – June 4, 2015
- PSI NRA Appendix B – January 19, 2016
  - 10 proposals selected from Appendices A and B
- PSI NRA Appendix C – September 15, 2016
- Proposals are Due – December 15, 2016



# Research Areas and Investigations

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- 39 Investigations are eligible for the NRA Appendix C
  - 8 in Combustion Science
  - 12 in Complex Fluids
  - 6 in Fluid Physics
  - 3 in Fundamental Physics
  - 10 in Materials Science
- Plan to add ~56 Investigations over the next 3 years
- Plan to release new NRA every 2 years





# 2016 Physical Sciences Informatics NRA - Appendix C



National Aeronautics and Space Administration  
NASA Headquarters  
Space Life and Physical Sciences Research and Applications Division  
300 E ST SW  
Washington, D.C. 20546-0001

## Use of the NASA Physical Sciences Informatics System

### NASA Research Announcement

NNH15ZTT001N NRA

### APPENDIX C

Soliciting Proposals for Use of the NASA Physical Sciences Informatics System for  
Combustion Science, Complex Fluids, Fluid Physics, Fundamental Physics, and Materials  
Science

APPENDIX NUMBER: NNH15ZTT001N – 15PSI\_C

Appendix Issued: September 15, 2016  
Notices of Intent Due: October 31, 2016 (5:00 pm Eastern)  
Proposals Due: December 15, 2016 (5:00 pm Eastern)

Catalog of Federal Domestic Assistance (CFDA) Number: 43.003

- Released: September 15, 2016
- Proposer's Conference WebEx Oct. 5, 2016
- NOIs Due: October 31, 2016
- Proposals Due: December 15, 2016
- 39 eligible experiments
- PSI Appendix C solicits ground-based research proposals from established researchers and graduate students to generate new scientific insights by utilizing experimental data residing in the PSI system in the Combustion Science, Complex Fluids, Fluid Physics, Fundamental Physics and Materials Science research areas. The NRA is available at:

<http://tinyurl.com/NASA-15PSI-C>

For additional information on the entire PSI database, visit:

<http://psi.nasa.gov>



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# ***Questions on Physical Science Informatics (PSI)***



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# ***MaterialsLab***

## ***Phase II***



# MaterialsLab Workshop Science Disciplines

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The NASA MaterialsLab Workshop, sponsored by NASA HQ and NASA MSFC, “brought together scientists and engineers from academia, industry, other government agencies and international space agencies to help NASA in identifying key engineering drivers and research priorities for development of the next generation of materials science experiments on the ISS.”

There were six discipline specific working groups:

**1. Biomaterials** – Workshop and subsequent Biomaterials TIM divided into three focus areas of research:

- a) **Biological Materials:** materials of biological origin, e g., proteins, biopolymers. Investigate fundamental phenomena in solidification and/or other processes of organization (nucleation, growth, self-organization, etc.)
- b) **Biomaterials:** materials substituting tissues or organs, aiding their regeneration, or interfacing with these, e.g., tissue scaffolds, implant materials. Primarily elucidate cell-material interactions affecting cellular functions, organization, differentiation, etc.
- c) **Biomimetics:** bio-inspired materials that emulate function and/or principles of optimization such as hierarchical structures, multi-functionality, e.g., synthetic nacre (bulk materials), omniphobic surfaces, including materials synthesized in aqueous environments.

**2. Glasses and Ceramics**

Workshop divided into four focus “highest priority” areas of research

- a. H-1 Melting and processing of new compositional regimes of glass forming oxide, non-oxide, and metallic liquids
- b. H-2 Measurement of critical thermo-physical properties of equilibrium and supercooled glass forming liquids
- c. H-3 Glass formation through control of nucleation and growth processes
- d. H-4 Development of new optical, electrical, and high strength materials

**3. Granular Materials**

Workshop identified two focus areas that resulted in identification of a high priority need for an ISS GMR facility:

- a. Facility to study stress-strain behavior of granular materials
- b. Facility to study granular materials and granular material interfaces



## 4. Metals

Workshop identified seven high priority topics:

- a. Understanding the Microstructure and Morphological Development of Dendritic Array Growth
- b. Thermophysical Properties
- c. Joining (Welding, Brazing, and Soldering)
- d. Influence of nucleation and Growth Kinetics on Solidification Microstructures in Metals and Alloys
- e. Techniques and Instrumentation
- f. Microstructural Development in Directionally Solidified Eutectic Alloys
- g. Technology Development
  - Applications include: Electrolytic Processing; Additive Manufacturing; and Liquid Phase Sintering (LPS)

## 5. Polymers and Organics

Workshop identified three high priority themes:

- a. Transient Interfacial Phenomena in Miscible Polymer Systems (TIPMPS)
- b. Phase behavior of supercritical CO<sub>2</sub> and Organic Compound
- c. 3D printing (themes 1 & 2)
- d. Microgravity Processing of battery electrodes

## 6. Semiconductors

Workshop identified four high priority topics:

- a. Bulk Growth of semiconductor compounds for high value sensors and detectors
- b. Meniscus-defined and semicontainerless semiconductor processing
- c. High temperature Processing of industrially relevant semiconductors
- d. Thermophysical property measurements



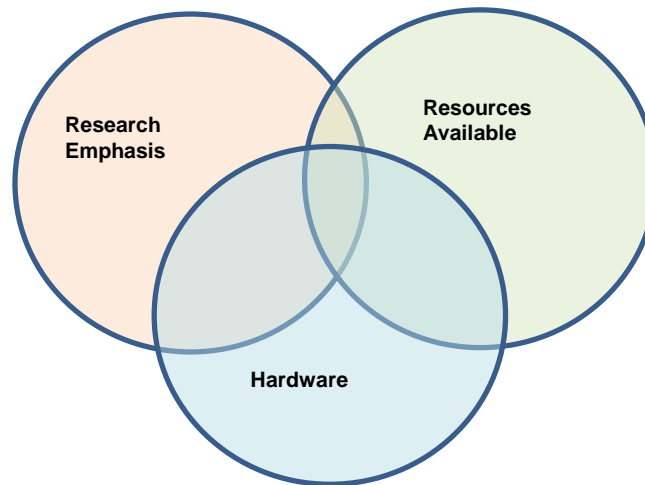


# MaterialsLab Phase II Special Study Approach

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- Revisit the findings of the MaterialsLab Workshop (April 2014)
- Synch with MaterialsLab Strategic Plan
- Determine if research emphasis has shifted
- Collect information on existing hardware and/or facilities
- Collect information on resources onboard ISS
- Match pairs between research emphasis / resources available / hardware





# *MaterialsLab Phase II Gap Analysis Results*

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- A literature survey confirmed ISS MaterialsLab Report and Strategic Plan is well aligned with specific predictive modeling and engineering technology gaps identified in
  - Presidents Materials Genome Initiative Strategic Plan (Dec. 2014)
  - National Research Council - Committee for the Decadal Survey on Biological and Physical Sciences in Space; Recapturing a Future for Space Exploration; Chapter 9 Applied Physical Sciences (2011)
  - National Institute of Standards and Technology (NIST) – Materials Measurement Laboratory (MML) Strategic Plan (2015)
  - NASA Office of Chief Technologist Roadmaps (July 2015)
  - Space Technology Implementation Plan (STIP) (date 2012)
- By focusing on utilizing the International Space Station to answer fundamental physical science questions, the ISS MaterialsLab will maximize the science benefit as well as the agency's return on investment.



# MaterialsLab Phase II Research Concepts



Discipline	MSFC EM POC	Concepts	Workshop ref
Biophysics	Sid Gorti	Biomaterials & Biomimetics - BioFilm Formation	III.1 Topic 5 and 6; IV.2 NSF. Also 2/27/15 Chart 19 from MaterialsLab recommendations
Biophysics	Sid Gorti	Biomaterials & Biomimetics - Development Efforts in Tissue Engineering and 3D Bioprinting	III.1 Topics 6 and 7; III.2RFI (p46); IV.2 NIH & NSF
Granular Materials	Jan Rogers	Development of a Granular Materials Research Facility	Page 82-104
Granular Materials	Richard Grugel	In-Situ Resource Utilization - Cement Studies	page 63
Glasses and Ceramics	Mike Sansoucie	Aerodynamic Levitator for ELF Support/Thermophysical Properties	Page 61-80
Glasses and Ceramics	Mike Sansoucie	Hybrid Levitator for ELF Support/Thermophysical Properties	Page 61-80
Metals	Richard Grugel	Soldering and Brazing	V. Page 118
Metals	Richard Grugel	Welding	V. Page 118
Metals	Richard Grugel	Additive Manufacturing (Metals)	V. Page 133



# MaterialsLab Phase II Research Concepts (cont'd)



Discipline	MSFC EM POC	Concept	Workshop ref
Polymers & Organics	Tracie Prater	Effective Interfacial Tension Induced Convection	I. Theme (1) p. 136; Theme (3) p. 137 II. II.1 p. 139 III. priority 1 p. 150; priority 3 p. 151 Note that the priorities here are really just the themes in I reiterated. IV. RFI-25/44 p. 152
Polymers & Organics	Tracie Prater	3D Printing of Polymers	I. Theme (1) p. 136; Theme (2) p. 137 II. II.3 p. 144 III. priority 1 p. 150; priority 2 p. 151 IV. RFI 52/50 p. 144
Polymers & Organics	Tracie Prater	Microgravity Processing of Battery Electrodes	I. Theme (2) p. 137 II. II.4 p. 148 III. Priority 2 p. 151 IV. RFI-14 p. 155
Polymers & Organics	Tracie Prater	Measurement of Extensional Viscosity in Microgravity	I. Theme (1) p. 136; Theme (3) p. 137 II. None (idea was not submitted as an RFI for MaterialsLab) III. Priority 1 p. 150; Priority 3 p. 151 IV. None (idea was not submitted as an RFI, but originated from my interviews with NIST SMEs to provide inputs to this PPBE)
Semiconductors	Martin Volz	High Temperature Furnace DDT&E and sustaining (MSRR insert with float zone capabilities)	Page 165-179; Topics 1-4
Semiconductors	Martin Volz	SUBSA Modifications for Physical Property Measurements	Page 175-179; Topic 4



## *MaterialsLab Phase II Next Steps*

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- Planning and formulation for MaterialsLab Phase II is underway
  - MSFC will presentation to NASA HQ in January 2017
- Adapt research focus to new administration directives and other priorities
- Continue to monitor progress and opportunities in each discipline area and adapt as required
- The culmination of all planning and formulation activities will result in a future NASA Research Solicitation
  - Assume FY19-FY20 timeframe





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# *Questions on MaterialsLab Phase II*



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# *Backup*



# Ring Sheared Drop Reference Experiment

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**Science Definition Team:** S. Gorti (NASA/MSFC), Amir Hirs (RPI), Juan Lopez (ASU), others (TBD)

**Collaboration:** Alzhewimer

**ISS Facilities/Hardware:** Containerless Processing /Ring Shear Drop Facility

**Objectives:** To study amyloid fibril formation upon perturbing the native structure of a protein by forces, via containerless bioprocessing and optical imaging techniques. Reference experiments may also nucleation and subsequent growth of amyloid fibrils .

**Microgravity Justification:** Design experimental apparatus and procedures to constrain centimeter scale protein solution in water to study fibrillization under various shear rates in the absence of solid walls, where containment is achieved by surface tension.

**Application/Impact:** Formation of amyloid fibrils is widely studied because of its association with numerous neurodegenerative diseases, including Alzheimer's and Parkinson's disease. Amyloid fibril formation is a which destabilized protein molecules in solution form nuclei and aggregate into fibrils. Decoupling the basic mechanisms that instigate protein destabilization and subsequent fibrillization is significant towards degenerative disease. The novel bioreactor to be developed for fibrillization studies will also have utility for biological systems.

**PSI Significance:** High. This Reference Experiment will provide data for a large variety of materials with impact on many industries, products, and applications, some of very high value.



# Ring Sheared Drop Reference Experiment

